U.S. PATENT APPLICATION
Docket #47176-00687
(Andrew Ref. No. 546)

BOX PATENT APPLICATION
Commissioner for Patents
Washington, D.C. 20231

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WAVEGUIDE ADAPTOR ASSEMBLY AND METHOD

INVENTORS:

Frank J. Graczyk, Gary E. Frigo, Jeffrey D. Paynter, and Ronald L. Tellas

BACKGROUND

Field of the Invention

The present invention relates generally to waveguides, and more particularly, but not by way of limitation, to a method of and apparatus for coupling a waveguide flange assembly to a waveguide.

Description of Related Art

Waveguides are commonly used for transmitting electromagnetic wave energy from one point to another. One of the more extensive commercial uses of waveguides is the transmission of electromagnetic signals from transmitting or receiving equipment. This transmission may occur, for example, between an equipment shelter and an antenna, often mounted on a tall tower. In general, the waveguide consists of a hollow metallic tube of defined cross-section, uniform in extent in the direction of propagation. Within the hollow tube, the electric and magnetic fields are confined, and, since the tubes are normally filled with air, dielectric losses are minimal. Commercially available waveguides may be either of the rigid wall or flexible variety and their cross sectional shapes may be rectangular, circular and elliptical. Such waveguide shapes are, for example, disclosed in U.S. Patent Nos. 3,822,411 to Merle and 4,047,133 to Merle.

It is generally necessary for waveguides to be coupled to transmitting or receiving equipment at some point. Both the design of the waveguide, as well as coupling systems for use therewith, are critical to the efficiency of the overall system and thus certain design parameters must be applied. For example, it is well known to preclude the generation of field variations with height and their attendant unwanted modes. It is similarly well-known to securely mount a waveguide within a waveguide flange connector in order to prevent reflection losses and impendence mismatches. Reliable and secure mountings are not,

however, always easy to accomplish. It is for this reason that waveguide flange and coupling assemblies have been designed and implemented for connecting waveguides one to the other as well as to receiving or transmitting equipment. Due to the variety of applications and variations in the design of such transmitting and receiving equipment as well as variations in the designs of waveguides, the waveguide flange and coupling assembly has become an area of intense design focus. Not the least of the reasons for the above referenced focus is the functional efficiency of the waveguide flange and coupling assembly. It is well known that trouble may occur either between the waveguide and its flange or between the two mating flanges of coupled waveguides as well as between a waveguide and equipment being connected thereto. Possible problems which may be encountered include VSWR reflected power, high vswr (voltage standing wave ratio), power leakage and arcing. It is thus critical to provide the appropriate coupling mechanism and methods of assembly for use therewith when linking waveguides to one another or to transmitting or receiving equipment.

Waveguide connectors including flange and coupling assemblies exemplifying prior designs are set forth and disclosed in U.S. Patent No. 3,374,450 to Stewart (the '450 patent) as well as U.S. Patent No. 3,500,264 to Floyd (the '264 patent). The '450 patent discloses a waveguide flange and coupling assembly and outlines various aspects of waveguide connection construction. A plurality of clamping elements including a collar and flange

member permit waveguide sections to be more easily assembled one to the other and both rigid and flexible waveguides are addressed. Likewise the '264 patent entitled "Connections Means For Waveguide Means" also discloses a method of and apparatus for connecting together sections of waveguides without soldering. U.S. Patent No. 3,821,670 assigned to Hughes Aircraft Company discloses a "universal type of waveguide flange" aligning and quick release assembly for coupling and decoupling abutting waveguide flanges. The above-referenced functional efficiency and substantially loss free connection aspects are similarly addressed in this reference.

The above-referenced patents address in particular the connection of waveguides one to the other. It is also important to provide an appropriate coupling mechanism with waveguides connected to transmitting and receiving equipment. In that regard, it is typical in the industry to manufacture waveguides, whether rigid or flexible, in standard lengths and shapes. Flanges are generally permanently mounted at one or both ends to allow for attachment to other waveguide sections or telecommunications equipment. Such waveguide flange and coupling assemblies are generally necessary in order to assemble the waveguide sections into a desired array and/or to desired equipment in order to transmit the electromagnetic wave energy between select points. The design of the waveguide flange for the waveguide flange coupling assemblies is thus critical in this aspect.

As stated above, not all transmitting and receiving equipment and not all waveguide sections are manufactured under the same design specifications. It has thus been common to manufacture and stock waveguide sections having different waveguide flange and coupling assemblies permanently affixed on the ends thereof. Certain applications will specify one kind of waveguide flange coupling assembly while another application may specify another. These variations in waveguide couplings can produce both manufacturing and inventorying problems because virtually identical sections of waveguides may be manufactured and then inventoried with different waveguide flange and coupling assemblies on the ends thereof. Some waveguide and flange assemblies will be immediately utilized while others remain in inventory until a particular demand arises. From a commercial efficiency standpoint, this is not a cost-effective approach.

Waveguide and waveguide flange coupling assemblies are critical to the telecommunication industry and necessitate similar production planning and inventory considerations relating to that of other telecommunications equipment. Parts must be kept in stock for particular applications despite the frequency of use. In a competitive economic environment it is, however, incumbent upon manufacturers and suppliers of equipment such as waveguides and waveguides flange adaptors for the telecommunication industry to be able to provide the requisite parts in a relatively short period of time. One approach to reducing inventory capital is to manufacture fewer parts having unique applications. The

present invention provides such an approach by utilizing a waveguide flange adaptor capable of multiple applications.

Summary of the Invention

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be obtained by reference to the following detailed description when taken in conjunction with the accompanying Drawings wherein:

FIG. A is a perspective view of a waveguide mounting assembly used in the prior art. 7

FIG. 1 is a perspective view of one embodiment of a waveguide and flange adaptor assembly constructed in accordance with the principles of the present invention;

FIG. 1A is a reverse perspective view of one embodiment of the FIG. 1 waveguide and flange adaptor assembly assembled in accordance with the principles present invention;

FIG. 2 is an exploded, perspective view of the waveguide and flange adaptor assembly of FIG. 1 and FIG. 1A further illustrating the mounting hardware utilized therewith for coupling waveguide flanges thereto;

FIG 2A is a reverse exploded, perspective view of the waveguide and flange adaptor assembly of FIG. 1 and FIG. 1A further illustrating the mounting hardware utilized therewith for coupling waveguide flanges thereto;

FIGS. 3 and 3A are enlarged perspective views of opposite sides of the flange adaptor of FIGS. 1 and 1A;

FIG. 4 is an exploded, perspective view of an alternate embodiment of a waveguide and flange adaptor assembly, illustrating the mounting hardware utilized therewith for coupling waveguide flanges thereto;

FIGS. 5A and 5B are enlarged, perspective views of opposite sides of the flange adaptor of FIG. 4;

FIGS. 6A and 6B are perspective views of opposite sides of another waveguide flange adapted for mounting to the flange adaptors of FIGS. 3-3A and FIGS. 5-5A and illustrating one aspect of the a mounting configuration thereof;

7B, 7C and

FIGS. 7A through 7D are enlarged perspective views of additional waveguide flanges adapted for mounting to the flange adaptors of FIGS. 3-3A and FIGS. 5-5A; and

8B, 8C and

FIGS. 8A through 8D are enlarged perspective views of additional waveguide flanges adapted for mounting to the flange adaptors of FIGS. 3-3A and FIGS. 5-5A.

DETAILED DESCRIPTION OF THE INVENTION

It has been found that the use of a waveguide flange adaptor for the mounting of a plurality of waveguide flanges thereto and semi-permanently affixed to at least one end of a waveguide can reduce the required inventory of waveguide assemblies. As referenced above, the use of waveguides is prolific in the telecommunication industry, where specifications for standard flange interfaces, including waveguide mounting flanges, vary

from one application to another. There are multiple reasons for such design variations. Flange interface standards vary in different regions of the world, and the designs of one manufacturer may require mating styles and configurations that are different from those of other manufacturers. The waveguides themselves are typically of standard dimensions, while a waveguide flange for coupling a standard waveguide to one transmitter may not be adapted for coupling to a flange interfaces of another manufacturer's equipment. For that reason, waveguide sections must be produced with a variety of mounting flanges, typically permanently secured on the ends thereof. One of the preferred methods of mounting a waveguide to a waveguide flange incorporates the use of molten solder. Although various disadvantages may exist in the use of solder, it is well known that reliable mounting configurations maybe affected with solder for maintaining the integrity of the flange interface with that of the waveguide and reducing inefficiencies associated therewith. Unfortunately, when a particular mounting flange is directly soldered to the end of a waveguide, that particular waveguide and flange assembly may only be used with equipment or other waveguides that have mating flange interfaces. As referenced above, certain waveguide flange interfaces are used less frequently that others, thus requiring more inventory and the concomitant investment of capital. It is an advantage therefore to provide a waveguide and flange adaptor that is designed for multiple applications, whereby the level of inventory for such hardware can be reduced. The present invention provides such a

system by providing a waveguide assembled with a flange adaptor on one or both ends thereof. The flange adaptor is designed for interfacing with a plurality of waveguide mounting flanges. In this manner, a single waveguide and flange adaptor can be utilized for a variety of waveguide flanges and related applications, while minimizing the requisite inventory issues. Also, if a customer is using the present invention and attempting to mount a waveguide to a radio, antenna, waveguide, or other standard flange interface, and that customer has ordered the wrong flange type, the supplier can simply rush the customer a number of the correct flange types so that field installation will not have to be deferred.

Referring to FIG. A, a prior art waveguide mounting assembly is shown where a flange is soldered to a rectangular waveguide in order to facilitate connection to a radio, antenna, or another waveguide. The flange abuts a flange interface which is affixed to the radio, antenna, or other waveguide. To facilitate connection between the flange and the flange interface, one might use screws, bolts, rivets, solder, etc. The disadvantage of the assembly pictured in FIG. A, lies in the fact that, as explained above, there are a variety of flange interfaces used in the industry and this assembly does not accommodate such a variety. Thus, in the prior art, users wishing to attach a waveguide a radio, antenna, waveguide, or other standard flange interface, had to keep an inventory of waveguides soldered to a variety of flanges to ensure that the user had a waveguide compatible to the flange interface that it sought to attache the waveguide to.

The present invention alleviates such a problem by simply having a waveguide adaptor assembly for connecting a waveguide to a standard flange interface on a radio, antenna or another section of waveguide. Rather than semi-permanently (as by soldering) attaching the waveguide directly to a flange, and then having to inventory all those combinations, the soldering is done on a flange adaptor which can be mated with a variety of flanges that are compatible with any of the various standard flange interfaces for a given waveguide size or cross-sectional geometry. The invention thus drastically reduces the inventorying problem.

Referring first to FIG. 1, there is shown a waveguide 10 to which is mounted to a flange adaptor 12 on a first end 14 of the waveguide into the waveguide side of the flange adaptor 12. Opposite the waveguide side of the flange adaptor 12 is the opposed flange side having a predetermined flange coupling interface for mating against a flange. It may be seen that the waveguide 10 is of the generally rectangular variety and, in this embodiment, is of rigid construction.

FIG. 1A illustrates a reverse perspective view of the waveguide-flange adaptor assembly of FIG. 1 connected to a flange 20. In order to secure waveguide 10 to flange adaptor 12, end 14 fits into a waveguide mounting region 70 on the waveguide side of the flange adaptor 12. In order to secure the flange adaptor 12 to the flange 20, threaded screws 42 are screwed into the adaptor side of the flange 20 to secure abutment between

the adaptor side of flange 20 and the flange side of the flange adaptor 12. This will be discussed in more detail below. Alternatively, as would be recognized by one skilled in the art, other fastening means may be used in place of threaded screws 42, such as rivets, bolts, welds, solder, etc. Also, in order to facilitate connection to another flange or mounting surface, apertures 40 through flange 20 allow for fastening means such as bolts, screws, rivets, etc. to be placed therethrough. In order to allow the waveguide adaptor assembly of the present invention to be compatible with the variety of flange interfaces used in the industry, the geometry of the flange interface side of flange 20 is varied depending on the geometry of the flange interface (not shown) for which the waveguide adaptor assembly is to be connected. However, to facilitate connection of the flange 20 to the flange adaptor 12, the adaptor side of flange 20 must always be compatible with the flange side of flange adaptor 12.

Referring now to FIGS. 2 and 2A, the first flange adaptor 12 of first end 14 is shown in an exploded view relative to waveguide 10 for purposes of illustrating the attachment of a waveguide flange thereto. In that regard, a waveguide flange 20 is shown with the appropriate hardware in accordance with the principles of the present invention. The waveguide flange 20 comprises one of a variety of waveguide flanges that may be utilized with the flange adaptor 12. Other waveguide flanges will be described in more detail below, and it should be noted that the particular mounting method and apparatus as

set forth in FIG. 2 may likewise be utilized relative to said flanges described in more detail below.

Still referring to FIGS. 2 and 2A, in order to secure the waveguide 10 to the flange adaptor 12, the flange adaptor 12 is adapted for receiving end 14 of waveguide 10 within a waveguide mounting region 70 (See Fig 2A) of the waveguide side of the flange adaptor 12. To provide for secure engagement, end 14 is typically soldered in place within the waveguide mounting region 70. In order to secure the flange adaptor 12 to the flange 20, apertures 47 are formed through the flange adaptor 12 to allow for receipt of threaded screws 42. When the components of FIGs. 2 and 2A are assembled, the threaded screws 42 go through apertures 47 and into corresponding apertures 72 (See Fig. 2A) of flange 20 to secure the flange interface side of flange 20 to the flange side 73 of flange adaptor 12. Apertures 72 of flange 20 are not bored completely through flange 20, but only bored with enough depth to allow threaded screws 42 to securely engage the flange adaptor 12 to the flange interface side of flange 20. In order to accommodate a gasket 80, made of silicone, neoprene, or the like, to facilitate air-tight engagement of the flange 20 and the flange adaptor 12, a groove 71 (see Fig 2) may be formed in the flange side 73 of flange adaptor 12. This is necessary to block the ingress of moisture and because the waveguide assemblies of the present invention may be pressurized.

Referring still to FIGS. 2 and 2A, the waveguide flange 20 is designed for mating with another flange (not shown) or the mating surface of equipment (not shown). As set forth above, secured mounting to such flanges and/or mating surfaces is critically important. For that reason, a plurality of apertures 40 are formed in waveguide flange 20, the apertures 40 being adapted to receive coupling members therethrough. In the event that the apertures 40 of waveguide flange 20 are not threaded, as certain flange apertures will be (e.g. FIGS. 5A AND 6B), securing hardware such as threaded nuts (not shown) would be provided in association with threaded bolts (not shown). Such assembly provides securement of the flange 20 with another flange (not shown) or the mating surface of equipment (not shown).

Still referring to FIGS. 2 and 2A, the bolts (not shown) are preferably pre-installed within the apertures 40 of the waveguide flange 20 when said flange is initially mounted to the flange adaptor 12. The purpose of this initial assembly is to provide the waveguide flange 20 with the necessary hardware for coupling to a mating flange or mating surface. In the event that hardware is known to be available in the mating surface or flange (not shown), the bolts would not necessarily be installed within the apertures 40 of waveguide flange 20.

Referring now to FIGS. 3 and 3A, there is shown an enlarged perspective view and a reversed enlarged perspective view, respectively, of the flange adaptor 12 (as seen in FIGS 1-2) for use with the rigid waveguide 10.

The present invention may also be used with a flexible waveguide with slight modifications to the flange adaptor. Referring now to FIG. 4, there is an exploded perspective view of the flange/waveguide assembly using a flexible waveguide 10A. A jacket 18 is typically provided around the waveguide 10A, however, in order to allow assembly to the flange adaptor 12A, the jacket 18 leaves the front end 14A of the waveguide 10A bare. To provide stabilization of the jacket 18 when waveguide 10A is mounted to flange adaptor 12A, a rear flange 24 is provide on flange adaptor 12A which adheres to the jacket 18. The adhesion of the jacket 18 to the waveguide 10 and flange adaptor 12 is preferably facilitated by the application of heat. The jacket 18 may be made of neoprene or the like, which will bond to metal surfaces when heated. In order to allow the threaded screws 42A of the present embodiment to be placed into the apertures 47A of the flange adaptor 12A, the flange adaptor 12A has an elongated region 25. This allows the threaded screws 42A of the present embodiment to be placed into the apertures 47A without impediment from the rear flange 24. The geometries and functions of the front end 73A of the flange adaptor 12A, the gasket 80A, and the flange 20A are identical to those describe in relation to the rigid waveguide assembly in FIGS. 1-2, and will not be repeated herein.

Referring now to FIGS. 5 and 5A, there is shown an enlarged perspective view and a reversed enlarged perspective view, respectively, of the flange adaptor 12A (as seen in

FIG. 4) for use with the flexible waveguide 10A. To accommodate a generally rectangular waveguide, the flange adaptor 12A of this particular embodiment has a generally rectangular passageway formed therethrough. As will be seen below, waveguide mounting flanges having variations in shape and size will be specifically set forth and shown. Other shapes and sizes are considered to be within the spirit and scope of the present invention.

In order to provide an area where the bare end 14A of the waveguide 10A can fit into the flange adaptor 12A, the flange adaptor 12A is provided with a waveguide mounting region 70A comprising a shoulder 58 to abut the end 14A of the waveguide 10A (seen in FIG. 4). To securely fasten the waveguide 10A to the flange adaptor 12A, the waveguide 10A of the present embodiment is typically soldered to the flange adaptor 12A when end 14A is properly disposed in waveguide mounting region 70A abutting shoulder 58.

Still referring to FIGS. 5 and 5A, the flange adaptor 12A is preferably formed of stainless steel, or the like, and may be milled from bar stock or initially cast and milled therefrom. Such manufacturing techniques are well known in the industry. Likewise, it is well known to connect a waveguide 10A of the type shown in FIGS. 4 and 4A to waveguide flanges with the use of solder or the like. It is for this reason that the shoulder 58 (see Fig 5a) is of sufficient length for receiving the requisite portion of the waveguide 10A as shown in FIG. 4 for the application of solder thereto. In order for the jacket 18 to have sufficient bonding area, the rear flange 24 must be of sufficient height. Similarly, as stated above, in

order to facilitate the joining of the flange adaptor 12A to the flange 20A, the elongated region 25 must be of sufficient length. As with the flange adaptor for the rigid waveguide assembly in FIG 2 and 2A, the flange adaptor 12A of the present embodiment has apertures 47A to facilitate threaded screws or another type securing mechanism, and a groove 71A (see Fig 5) to allow for a gasket to allow air-tight joining to a flange.

There are a number of standard mating flanges presently in the field. The present invention allows the waveguide/flange adaptor assemblies of FIGS. 2-2A and 4 to be connected to any of these standard mating flanges just by altering the geometry of flange 20 and 20A seen in FIGS 2-2A and 4. In order for these alternative flanges to be compatible with the flange adaptor, a rear portion of the flange should be raised (as with flange interface side of flange 20 in FIG. 2A) and have partially drilled apertures therethrough (as with apertures 72 in flange interface side of flange 20 in FIG. 2A) that line up with apertures 47 and 47A of the flange adaptors 12 and 12A (FIGS. 3-3A and 5-5A), respectively regardless of the geometry of the flange used to ensure compatibility in the field. FIGS 6A-8D illustrate a variety of geometries of flanges that may be used with the present invention to enable compatibility with other mating surfaces in the field. It should be understood that the rear faces of each of these flanges have raised rear portions 76 (seen in FIG. 6B) with partially drilled apertures 75 (seen in FIG. 6B) that line up with apertures 47 and 47A of the flange adaptors 12 and 12A.

Referring now to FIG. 6A, there is shown a perspective view of a alternate waveguide flange 100 which may be utilized in conjunction with the flange adaptors 12 and 12A of the present invention (see FIGS. 3-3A and 5-5A). Waveguide flange 100 is formed of a generally rectangular body which includes a plurality of holes 104 formed therethrough and adapted for coupling to a mating surface. A generally rectangular passage 106 is formed centrally through the waveguide body 102 and is further circumscribed by a recess 108 formed therearound. The recess 108 is preferably formed for the receipt of a gasket to be utilized in the mounting of waveguide flange 100 to a mating surface.

Referring now to FIG. 6B, there is shown a perspective view of the rear surface of the waveguide flange 100 illustrating certain aspects of the construction thereof. As stated above, in order to accommodate mounting to the flange adaptors 12 and 12A of FIGS. 3-3A and 5-5A, a raised rear portion 76 is provided with threaded holes 75 partially drilled therethrough for securely receiving threaded screws 42 seen in FIGS. 2-2A and 4. The spacing of plurality of holes 104 is selected relative to the hole patterns of the mating surface.

Referring now to FIG. 7A through 7D, there are shown four different rectangular waveguide flange designs. In FIG. 7A, a rectangular waveguide flange 120 is formed with apertures 122 comprising a hole pattern 123. The face 124 of waveguide flange 120 includes a recess 126 which is formed around a central passageway 125. The recess 126

may be seen to be found at a greater depth than that shown in FIG. 6A for recess 108. This is yet another example of variations to waveguide flange designs.

Referring now to FIG. 7B, there is shown a rectangular waveguide flange 130 having a plurality of apertures 132 in a hole pattern 134 that is distinctly dissimilar to the hole pattern 123 of flange 120 of FIG. 7A. The waveguide flange 130 includes a generally rectangular central passage 136 that is adapted for mating engagement with the flange adaptors 12 and 12A of FIGS. 3-3A and 5-5A as described above. The variation in the hole pattern 134 of waveguide flange 130 illustrates the fact that the waveguide flange 130 is adapted for receiving a variety of hole patterns for the securement of mating surfaces thereon.

Referring now to FIG. 7C, a waveguide flange 140 is set forth and shown in yet a different configuration relative to the waveguide flanges of FIG. 7A and 7B. Although waveguide flange 140 has a plurality of apertures 142 forming a pattern 144 which appears similar to the pattern 123 of apertures 122 in waveguide flange 120 of FIG. 7A, the face 146 of waveguide flange 140 is planar. It is not formed with a gasket recess, as was the case with waveguide flange 130 of FIG. 7B.

Referring now to FIG. 7D, there is shown a waveguide flange 150 having a plurality of holes 152 in a pattern 154. A central passageway 156 is found therethrough. It may be

seen that the thickness of waveguide flange 150 is less than that shown for the waveguide flanges in FIGS. 7A-7C.

Referring now to FIG. 8A there is shown a waveguide flange 160 having a distinctly dissimilar shape to that of the waveguide flanges of FIGS. 6A and 6B, and 7A through 7D. Waveguide flange 160 presents a circular, or round shape with a rectangular passage 162 formed therethrough. The face 164 of round waveguide flange 160 is likewise constructed with round recesses 166 and 167 formed within face 164 thereof. The plurality of apertures 169 are formed therein in an aperture array 161. It may be seen that aperture array 161 is circular in shape and will thus require rear face (not shown) having a shape and size accommodating mounting to the flange adaptors 12 and 12A.

Referring now to FIG. 8B, there is shown yet another round waveguide flange 170 having a generally rectangular passage 172 formed therein. The plurality of apertures 173 are formed in a hole pattern 174. The face 176 of round waveguide flange 170 is substantially planar in construction.

Referring now to FIG. 8C, there is shown yet another waveguide flange 180 having a plurality of apertures 182 formed in a hole pattern 184 therearound. A generally rectangular passage 186 is formed in the face 188 of the generally round waveguide flange 180. A recess 189 is formed in the face 188 and provides a surface for the seating of a gasket therein.

Referring now to FIG. 8D, a generally rectangular waveguide flange 190 is shown formed with a plurality of apertures 192 formed therein in an array 194. A generally rectangular passageway 196 is likewise formed therethrough. A plurality of the apertures 192 are threaded. For example, holes 197 include dotted lines found across the rear surface 198 of waveguide flange 190. As referenced above, some mating surfaces are designed with alternating threaded and clearance holes.

It is thus believed that the operation and construction of the present invention will be apparent from the foregoing description. While the method and apparatus shown or described has been characterized as being preferred it will be obvious that various changes and modifications may be made therein without departing from the spirit and scope of the invention as defined in the following claims.